Materials Engineering Branch

TIP*

No. 060 Bearing Preloads

Author(s): A. J. Babecki Contact: (301) 286-6882

Ball bearings in spacecraft applications are normally used in pairs and are preloaded axially against each other to remove the play, or looseness, in them. In addition to providing some rigidity to the shaft on which the bearings are mounted, the preload on the bearings minimizes the sliding of the balls in the raceway ball grooves. Sliding of the balls is detrimental to the lubrication system and the life of the hearings. However, an excessively large preload also tends to reduce the useful life of solid film lubricated bearings, as well as liquid or grease lubricated bearings if their operation is in the boundary regime where ball-to-race contact is made.

Many designs of spacecraft mechanisms specify high axial preloads to prevent one or more of the bearings from becoming unloaded during launch vibration. It is believed by some designers that such unloading might cause impacts within the bearings that would result in the formation of ball Brinell impressions that would result in jittery operation and possibly lead to reduced bearing life. Once the hardware is in the zero G environment of earth orbit, the high preloads are no longer useful and, in fact, are detrimental as discussed above. Therefore, the axial preload on the bearings should be kept to the minimum that is necessary to remove the axial play if mathematical analysis indicates that brinelling will occur. This should be verified by actual test or the design should include some kind of device to carry the launch loads that otherwise would be imposed on the bearings.

Axial preloads are of two types depending on the application techniques (1) a hard preload applied by means of nuts, bolts or screws which force the ground bearing races against each other or against precision ground separation spacers and (2) a soft preload applied by compliant members, such as springs, that apply an axial load depending upon the spring rate and displacement of the compliant members. In this case, separation spacers are not required.

In case (1), the capture of metal or other particles between the mating faces will affect the actual preload, as will any settlement of the spacers, bearings or locking members as a result of vibration. Additionally, other small movements within the system, such as those caused by thermal expansion or contraction or wear will change the preload, sometimes increasing it. In most cases, the preload is not precisely known because of the difficulty of measuring it. For case (2) the compliant member applying the preload is able to accommodate the above-mentioned conditions without a significant change in the preload because the movements are small and are well within the displacement capability of the spring member. Additionally, because the spring load vs. deflection (spring rate) of the compliant member can be measured prior to assembly, the magnitude of the preload can be measured accurately by its deflection after assembly. The one objection to the compliant case is that, during the vibration loading of launch, the bearings temporarily may become unloaded or may even move axially. Whether this condition would cause a problem will have to be evaluated.